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ABSTRACT

A study was done of the relation of time for individual study versus instruction time in a non-traditional, problem-based medical curriculum at the University of Limburg (Netherlands). The study collected data on 86 courses conducted in 5 consecutive academic years. In this problem-based approach, each curriculum year in the first 4 years comprises six 6-week courses which are organized around interdisciplinary themes central to medicine. During each course students met twice a week for a 2-hour small group tutorial in which problems were analyzed and learning goals formulated. Most of the learning took place individually. Scheduled activities included 4 hours a week of small-group tutorials, 2-to-4 hours of lectures and 2-to-4 hours of training in medical skills. The independent variable was the amount of instruction time and the dependent variable was the average amount of time spent on individual study. The individual study time was measured by asking students after each course to estimate the number of hours per week he or she spent on self-directed learning activities. Results of data analysis indicated that increasing instruction time generally led to a diminishing increase in individual study time. Included are 4 figures, 1 table and 19 references. (JB)

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Exploring a model of study time allocation in a problem-based medical curriculum.

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INTRODUCTION

Study time appears to be a crucial factor in influencing achievement. In prominent psychological models of school learning time is also a central construct. This is especially the case for those that are explicitly "time-driven". These models --for example those of Bloom (1976), and Cooley and Leinhardt (1980)-- find their origin in Carroll's (1963) work. Carroll proposed a theory, which maintains that individual students will master instructional objectives to the extent that they are allowed and are willing to invest the time needed to learn. Empirical investigations that attempted to associate time to learn with cognitive achievement have more or less confirmed Carroll's theory. For example, Gettinger (1984a) found that the ratio of time spent and time needed does appear to be strongly related to learning (average correlation $\pm$ .50). Her findings support Carroll's model of school learning and stress the importance of spending adequate time in learning, relative to amount needed, to maximize achievement. Other investigators found similar correlations (r's varying between .13 and .59) between time spent on learning by itself and achievement (Fredrick & Walberg, 1980). Gijselaers and Schmidt (1990) report a correlation of .42 between time spent on self-study and achievement in a problem-based medical curriculum.

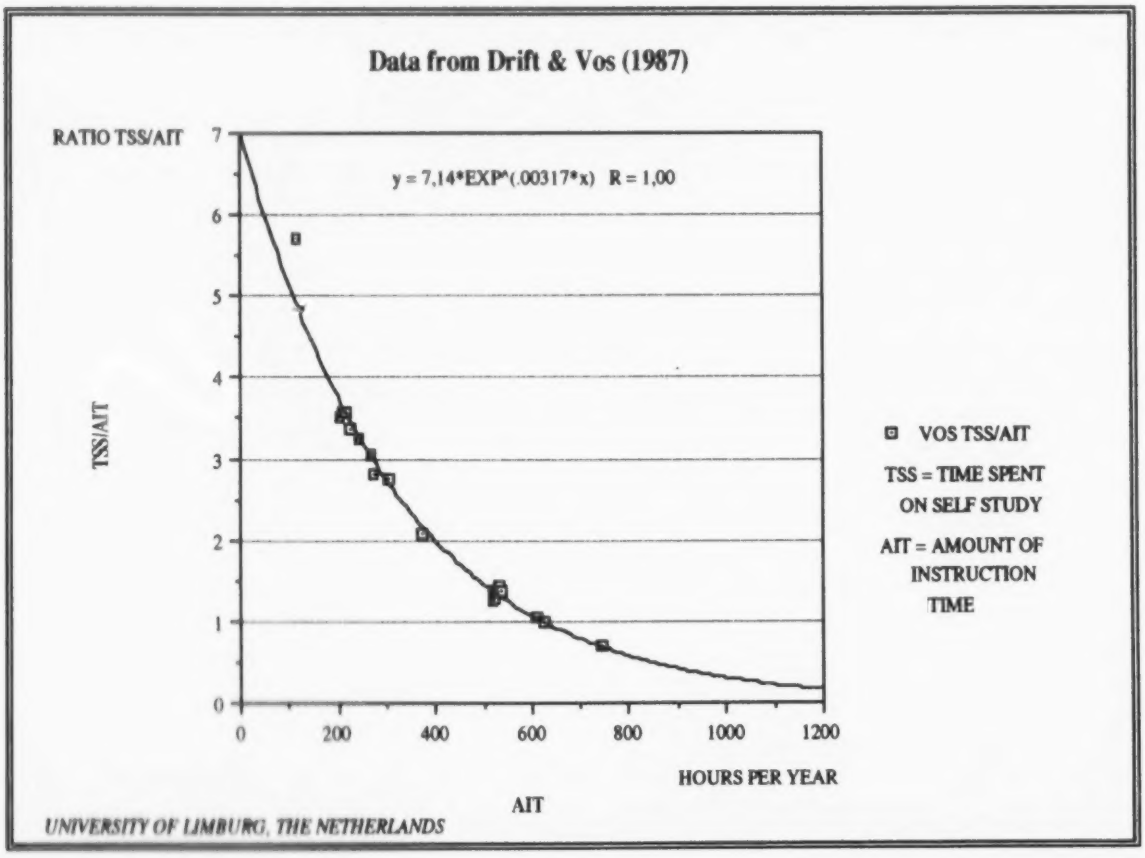
Since time to learn is an important variable in relation to educational achievement, the question may be raised how time spent on learning can be *maximized*. According to Carroll's model, the amount of time needed to learn instructional materials will partly depend on whatever time is necessary to adjust for poor quality of instruction. Consequently, poor quality of instruction will increase study time beyond what it would be under optimal conditions. This theoretical notion was empirically supported by Bloom (1976). He conducted a series of investigations to evaluate the effects of quality of instruction on time to learn and achievement. He found that improving instructional quality (provision of instructional cues, providing informative feedback) resulted in a decrease in time to learn. However, further inquiry into the relationship between quality of instruction and time to learn has been complicated by the difficulty to find a valid index of instructional quality (Gettinger, 1984b).

Walberg (1988), and Fredrick and Walberg (1980), claim that, in addition to variables as quality of instruction and student aptitude, *quantity* of instruction would be a good predictor of time to learn and, hence, of achievement. They suggest that essential factors in the process of schooling (e.g., quality of instruction) only may have their effects to the extent that students are given time to work. Accordingly, time spent on self-study is a variable which has a complementary or trade-off relationship with collective instruction time. Walberg and Tsai (1984) argue that it seems implausible that in the case where amount of instruction increases, learning continues at the same rate indefinitely if for no other limits than fatigue and the number of waking hours in the day. The 10th hour of a 10-hour instruction day will probably yield less achievement than the first hours of an instruction day. They eventually found evidence that instruction time and achievement have a

diminishing return relationship. Steady increase of instruction time may even worsen achievement beyond some turning point.

Dutch researchers maintain that this association also exists for quantity of instruction and time spent on self-study (Vos, 1985; Van der Drift & Vos, 1987). They challenge the view that more instruction time is always better, because surplus of instruction time may eventually affect educational effectiveness due to lack of time for self-study. They assume that diminishing and occasionally even negative returns may show up when instruction time is increased indefinitely, while other variables are held constant. This implies that increasing amounts of instruction time beyond an optimum may be associated with an actual decrease in self-study. Detailed studies of how students spend their time in various curricula of Dutch universities have confirmed this hypothesis. Results show that the average net time spent on self-study is strongly related to the average net time spent on class attendance. This relationship is, however, not a simple linear one. It can be expressed in figure 1 as a negative exponential function which has, in the studies conducted by Vos (1985) and van der Drift and Vos (1987), a perfect fit with the obtained self-study time data (R^2=1.0).

Figure 1. Association between amount of instruction (AIT) and time spent on self study (TSS).



These studies are even more important considering modern findings on the nature of cognition. Many investigations have shown that competence is primarily not fostered by teaching to deliver knowledge, but through teaching to engender specific kinds of cognitive activity. It is assumed that active engagement in the pursuit of knowledge and skill facilitates knowledge acquisition and knowledge organization (Glaser, 1991). A view quite different from that in which instruction supplies students with knowledge and accords them a passive role in learning.

Problem-based curricula are based on the principle that students have an active role in learning. According to Schmidt (1983) problem-based learning optimizes student learning because discussing problems facilitates the activation of relevant prior knowledge which, in turn, enables students to process new information in a better way. This requires a view on education in which learning is more important than teaching (Barrows, 1984). Consequently, self-directed learning must be stimulated explicitly and sufficient time should be available to spend on individual study. It may therefore be evident that in designing problem-based curricula and instructional practices opportunities should be examined to optimize time to study in relation to time needed for instruction. Instruction (working in small group tutorials, skills training etc.) should stimulate students, or be the driving force, to spent time on study.

Over the past few years analytical frameworks have been developed in primary, secondary and post-secondary education to provide curriculum designers tools for optimizing time to study in relation to the time needed for instruction (Walberg, 1988; Gettinger, 1985; Vos, 1985; Drift & Vos, 1987). Vos's studies were conducted in the setting of university teaching. They are very important for educational practice, given that instruction time and time spent on self-study are scarce resources in higher education. Therefore, they deserve continued investigation because of their theoretical and practical possibilities. However, Vos's studies appear to have three constraints: 1) The evidence is limited to a small amount of observations (18 university curricula); 2) The external validity is restricted to university curricula which follow traditional approaches to education (e.g., lecturing as a primary teaching approach); and 3) His unit of analysis was at the level of curricula (net time per curriculum-year). It would be interesting to see to what extent the findings of Vos (1985) and Drift and Vos (1987) could be extended to singular courses of shorter duration. The present investigation is an attempt to remedy these shortcomings. 86 six-week courses in a non-traditional, problem-based, curriculum were included in a further inquiry into the relationship between quantity of instruction and time spent on self-study.

METHOD

Sampling

Data on 86 courses conducted in five consecutive academic years were available. The data used in the analysis were obtained from the medical school of the University of Limburg in the Netherlands. The educational program of this medical school is based on the principles of problem-based learning. Each curriculum year in the first four years comprises six six-week courses which are organized around interdisciplinary themes central to medicine. During each course students met twice a week for a two hour small group tutorial in which problems were analyzed and learning goals formulated. Most of the learning took place individually. Scheduled activities usually included four hours a week of small-group tutorials, two to four hours of lectures, and two to four hours of training in medical skills. Instruction time was minimized in order to provide optimal space for self-study (Schmidt, 1983).

Variables

The independent variable in this study was amount of instruction time (AIT). AIT was defined as the net time per course spent on instruction attendance: Attendance of tutorial groups, lectures, skills training and other activities. For all instruction activities percentages of attendance rates were available. Therefore, for each instruction activity the amount of instruction hours was multiplied with attendance rate for this activity. This was defined as net time for instruction attendance. The AIT for each course was calculated as the total of all net time instruction attendances.

The dependent variable in this study was the average amount of time spent on self-study (TSS). TSS was measured by asking students after each course to estimate the number of hours per week spent on self-directed learning activities. Studies have shown that this method provides a reliable and valid indicator of TSS (Gijselaers, 1988). Moust (in prep.), for example, conducted a detailed study in which students of the Faculty of Law (University of Limburg) responded to this question at the end of a course. In addition, they were required to record all their study activities and time spent on independent learning in a logbook. At a course level estimates of TSS per week were the same for both methods. At an individual level both measures correlated .60. These results support the validity of the measurement of the dependent variable.

A TSS/AIT ratio was calculated at the course level for each course, by dividing the TSS score (time spent on self-study) by the AIT score (amount of instruction time). This ratio represents the return of one hour instruction time: time spent on self-study. For example a TSS/AIT ratio of 3 for a particular course can be interpreted as follows. Given the total amount of instruction time; every separate hour of instruction time resulted in 3 hours time spent on self-study.

RESULTS and DISCUSSION

To investigate the association between AIT and TSS, TSS/AIT was regressed on AIT using both a linear and a natural logarithm model. The natural log model was applied following suggestions by Vos (1985). According to Vos, the association between TSS and AIT may be expressed as an exponential function

$$(1)\ TSS/AIT = ae^{-(b*AIT)},$$

where TSS denotes average net time spent on self-study, AIT is average amount of instruction time, and a and b are regression constants.

According to this function, an increase in AIT will result in an exponential negative decrease of the ratio TSS/AIT. Vos showed that his data (consisting of 18 cases) fitted this curve perfectly (see figure 1: $R^2 = 1.0$; a = 7,14; b = .00317).

To calculate the a and b weights for regression equation (1) applied to our data, the natural logged version of this equation was taken. This equation can be written as

$$(2)\ \ln [TSS/AIT] = \ln [ae^{-(b*AIT)}]$$

(2) can be rewritten as

$$(3)\ \ln [TSS/AIT] = \ln (a) - b(AIT),$$

which is a linear regression equation where ln(a) denotes the intercept and where b(AIT) represents the slope of the regression equation. The association between the ratio TSS/AIT and AIT was assessed by using the linear regression module of SPSS/PC.

Tests of normality of the variables "ratio TSS/AIT", "AIT", and "TSS" were conducted through the SPSS "condescriptive" package. This package calculates measures of skewness for distributions of variables. The values reported for skewness did not lead to rejection of the assumption of normality for distribution of the variables at $p \leq .01$.

Application of the natural log model proposed by Vos resulted in a reasonable fit with the data from the 86 courses: $R^2 = .48$, $F(1, 84) = 77.579$ $p < .001$ a= 4.33 and b= .08. The linear model produced a similar fit: $R^2 = .47$, $F(1, 84) = 75.34$, $p < .001$, a= 3.42 and b= -.144.

Table 1 displays the univariate statistics of TSS, AIT and TSS/AIT. Figure 2 (exponential curve fitting) and figure 3 (linear curve fitting) show graphs of the ratio TSS/AIT versus AIT for our data.

Table 1. Univariate statistics for amount of instruction (AIT) and time spent on self-study (TSS).

Variable and Categories	No.	Mean	SD
AIT	86	11.3	2.0
TSS	86	19.1	3.8
TSS/AIT	86	1.7	.2

The plotted cases clearly demonstrate diminishing returns for increased amounts of instruction (AIT) to amounts of self-study time (TSS). That is, an increase in AIT results in a diminishing increase in TSS/AIT and, hence, with TSS. These graphs may be interpreted as follows. One hour increase in instruction time will result in less time spent on self-study for one preceding hour instruction time. For example, in figure 2 when AIT is equal to 9 hours, students will approximately spent 2.0 (ratio TSS/AIT) * 9 = 18 hours on self-study. However, when AIT would, for instance, equal 17 hours (which is an increase of 8 hours), only an increase in TSS of 2 hours would result, because, according to the model, students would only spend 1.2 * 17 = 20 hours on self study (TSS).

Figure 2. Association between ratio tss/ait and ait estimated with exponential curve fitting on the data-set of the problem-based medical curriculum of the University of Limburg.

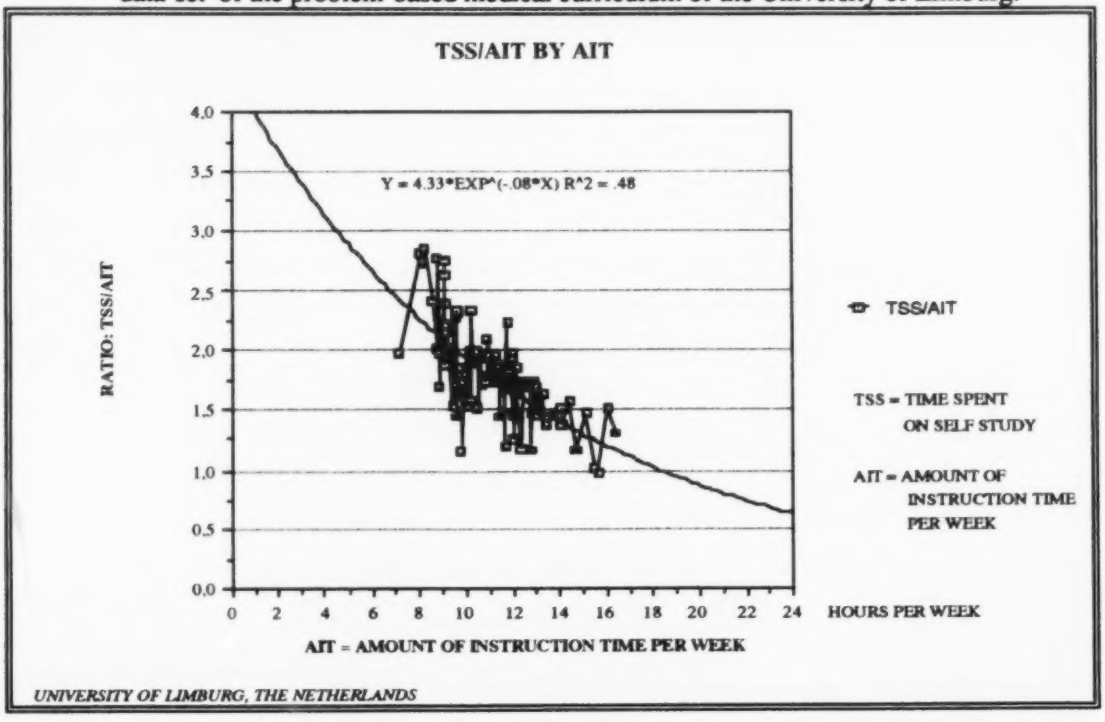
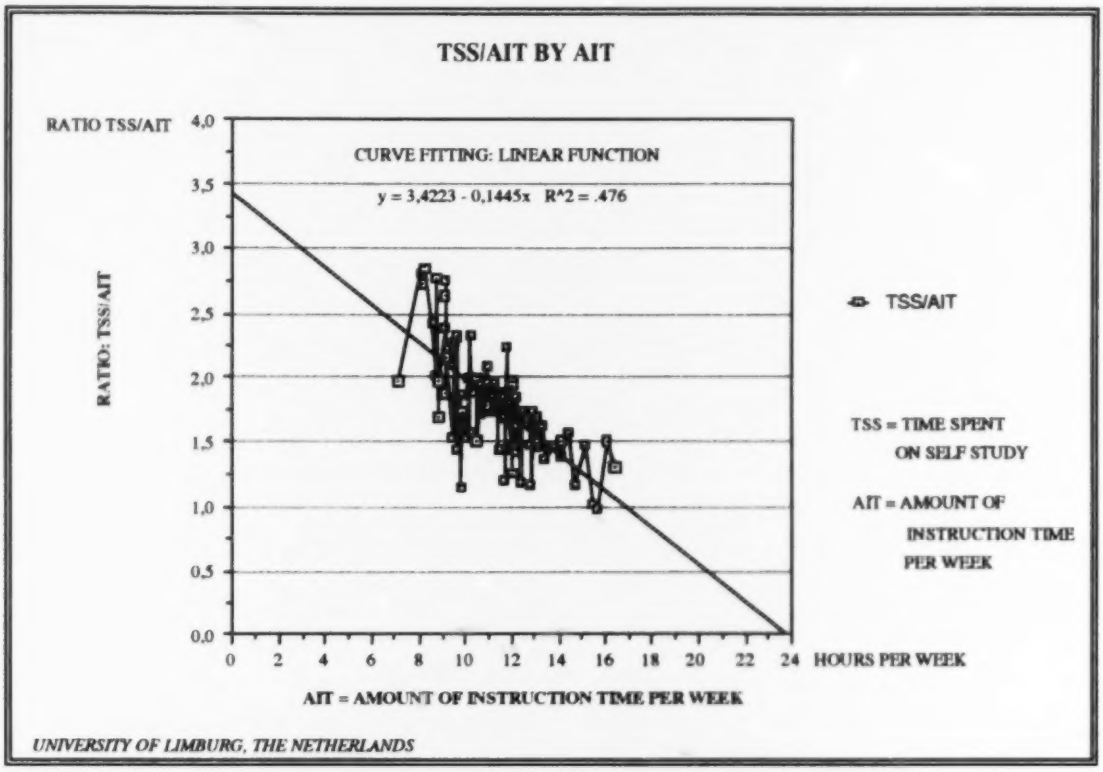


Figure 3. Association between ratio tss/ait and ait estimated with linear curve fitting on the data-set of the problem-based medical curriculum of the University of Limburg.



The results of the various analyses carried out, generally support the theories of Vos (1985), and Walberg and Tsai (1984). Increasing instruction time generally leads to a diminishing increase in self-study time. Our data show an acceptable fit with the natural log model postulated by Vos.

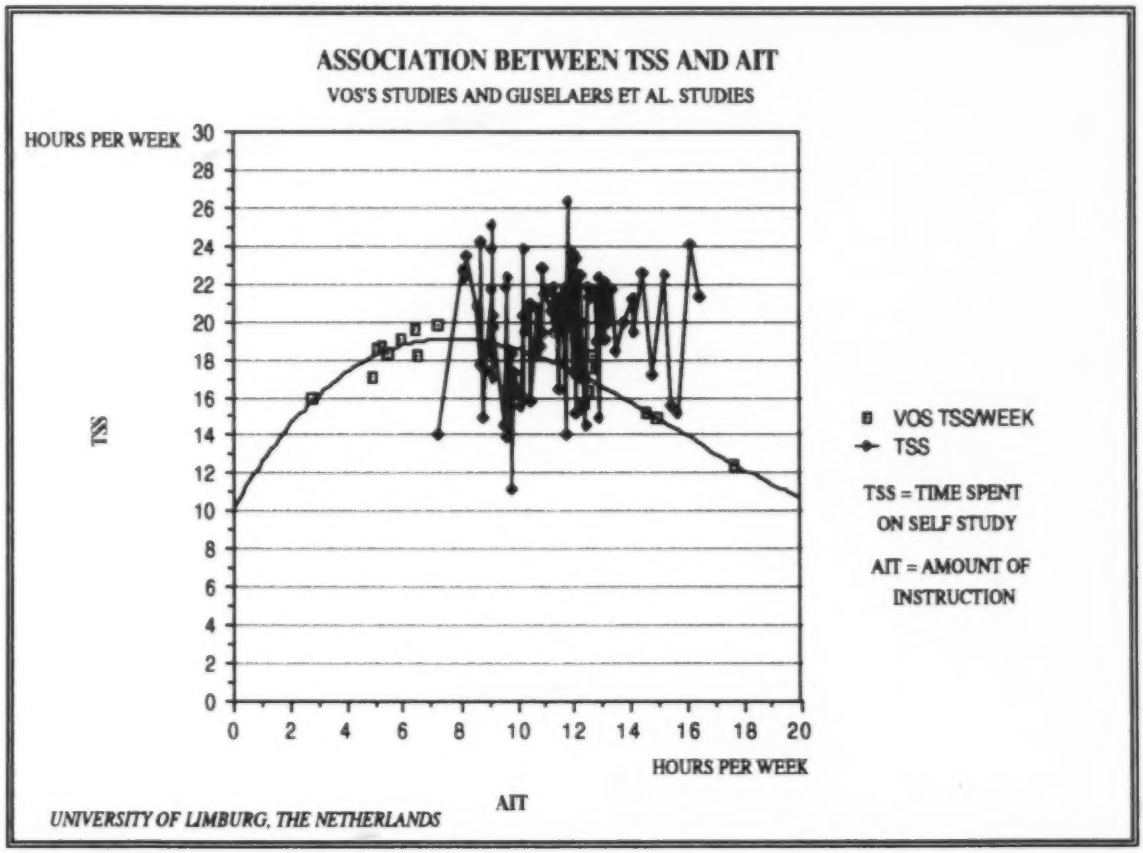
Theoretically, following the outcomes of this investigation, it would be possible to raise study time to a level as desired by university teachers. For example, in the Netherlands the theoretical level equals 1700 hours net per year, which implies that students spent five full days per week on study assignments (instruction and study) during 42 weeks per year. Only the number of scheduled activities, or amount of instruction, needs to be extended.

However, as figure 2 and 3 show, this extension would yield diminishing returns: an increased amount of instruction generates a diminishing increase of time spent on study. To evoke study activities, taken together 40 hours per week, instruction should be increased at a level of 24 hours per week. This level is associated with a ratio TSS/AIT of .7. The total amount of study activities (AIT and TSS) would approximately be: 24 hours (AIT) + 24 * .7 (TSS/AIT) = 40.8 hours per week. In the Netherlands, however, the empirical maximum of average study load in university curricula is about 1300 hours per year. Under the present

circumstances, optimizing time spent on study and minimizing instruction time, takes place within the constraint of 1300 hours per year.

The model of Vos contains an interesting peculiarity which is not found in our data. This peculiarity can best be demonstrated in Figure 4, which displays both sets of data plotted with instruction time (AIT) on the x-axis and self-study time (TSS) on the y-axis. In contrast to the data of the present authors, Vos found at the lower end of the AIT scale a steep increase of TSS associated with an increase of AIT, before the relationship reverses. This means that curricula (or courses) with very few hours of formal instruction are also characterized by a low level of study time and increases in instruction time would be associated with increases in self study time. Beyond an optimum, however, this relationship is reversed. That is why Vos postulated an exponential model as the best description of his data.

Figure 4. Association between tss and ait . Overlay plot of Vos' data and Gijselaers et al. data.


ASSOCIATION BETWEEN TSS AND AIT
VOS'S STUDIES AND GIJSELAERS ET AL. STUDIES
HOURS PER WEEK
TSS
AIT
HOURS PER WEEK
0 2 4 6 8 10 12 14 16 18 20
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
VOS TSS/WEEK
TSS
TSS = TIME SPENT ON SELF STUDY
AIT = AMOUNT OF INSTRUCTION
UNIVERSITY OF LIMBURG, THE NETHERLANDS

Our data fail to show this interesting peculiarity, simply because among the 86 courses investigated none had an AIT less than 7 hours. Therefore, a linear model seems to describe the present data as good as the exponential model. It is important to note, however, that the Faculty of Economics and Business Administration at the University of Limburg (which also

has a problem-based curriculum) has for each course a fixed AIT of 6 hours per week. In this faculty, TSS/AIT ratio's were found oscillating around 4.2, and TSS is approximately 24 hours per week. This result would imply that the model of Vos is more plausible than a linear regression model.

It is also interesting to note that the pattern of the authors' plotted data deviate form Vos's data at the point where AIT is larger than 9 hours per week. According to Vos an AIT of 9 hours per week reflects the turning point between AIT and TSS. Our data fail to reveal such a turning point. TSS of the problem-based curriculum increases, although slightly, even after the turning point of of nine hours. This results may be assigned to a possible positive effect of problem-based programs on students' intrinsic motivation, which in turn may influence the willingness to spent time on study. Such an interpretation of the data is however very hypothetical considering the stage of investigation and the practical problem of comparing two data sets which are based on different methods of data collection. It is, however, clear that further study is required in cases where AIT is either very low (< 8 hours) or very high (> 18 hours).

Finally, it is worthwhile to mention that curve fitting could be increased in those cases when only biophysical courses were selected (excluding the psychosocial medical courses of the program). The association between ratio TSS/AIT and AIT increased from $R^2 = .48$ to $R^2 = .60$ (N=71) in case of exponential and linear curve fitting. This result suggests that students' learning activities and the willingness to spend time on study is also dependent of course contents. Research from Dolmans, Gijselaers, Schmidt and Meer (in prep.) showed that students tend to prefer problems with a highly biophysical character above problems which are psychosocially oriented. These results may provide an explanation for the fact that data from biophysical courses fit the postulated curve slightly better.

CONCLUSION

Previous research on school learning has acknowledged the importance of time allocated to study (Gettinger, 1985). All other things being equal, for example quality of instruction, students' prior knowledge and learning skills, increasing time spent on individual study will have a positive return on achievement or on knowledge acquisition. Modern cognitive psychology suggests that instruction should stimulate students to develop self-directed learning skills and devote time to active learning (Glaser, 1991). It may be evident that curriculum designers of problem-based programs explicitly try to establish such a learning situation featured by a great emphasis on self-directed learning, teacher independent study and reduction of instruction time. However, a prominent or even paradoxical question is how time spent on study can be optimized in a situation where curriculum designers would like to minimize instruction time. It is apparent that such a learning situation could be created according to Carroll's (1963) paradigm by increasing quality of

instruction, all other things being equal. Higher instructional quality would would require less learning time to master an instructional unit. There is indeed some evidence that an individual's time needed for learning is an alterable characteristic that can be minimized through appropriate teaching strategies (Gettinger, 1983).

Empirical investigations that attempt to examine time to learn, within the paradigm of Carroll (1963), often follow an approach in which quality of instruction plays an important role. Two major difficulties may be identified following this approach (Gettinger, 1983). The first difficulty lies in arriving at a reliable index for quality of instruction. The second difficulty is the question how educational quality may be modified. Improving educational quality is in many cases a painstaking and difficult process which takes many hours of course design into account. In addition course modification should follow specific operationalized criteria to make valid inferences possible from changes which might occur in learning time.

Alternative methods, requiring less hours and expertise of educators, would be preferable if effective and efficient. The results of this investigation suggest that such a method exists. Quantity of instruction, or amount of instruction is a variable that also seems to affect learning time. Regression analysis showed significant treatment effects for amount of instruction (AIT) on time spent on study (TSS).

The findings of this study accord well with the empirical studies of Vos (1985), van der Drift and Vos (1987), and Walberg and Tsai (1984). Beyond 7 hours of instruction time per week amount of self study results in lower increases, suggesting a diminishing return in TSS for each hour of formal instruction beyond that point. From an educational development perspective, the central role played by AIT on TSS is quite encouraging. It suggests that the amount of time students are willing and able to engage in self study could be influenced by simply changing the amount of instruction. If that is true, an efficient and effective allocation of resources for learning becomes better possible. Hence, research dealing with the effects of AIT on TSS and subsequent educational achievement should be an area of primary interest to investigators of classroom learning.

REFERENCES

Barrows, H. (1984). A specific, problem-based, self-directed learning method designed to teach medical problem-solving skills, self-directed learning skills, self-learning skills and enhance knowledge retention and recall. In H.G. Schmidt and M.L. De Volder (Eds.), *Tutorials in problem-based learning*. Maastricht: van Gorcum Publishers.

Bloom, B.S. (1976). *Human characteristics and school learning*. New York: McGraw-Hill.

Carroll, J.B. (1963). A model of school learning. *Teachers College Record, 64*, 723-733.

Cooley, W.W. & Leinhardt, G. (1980). The instructional dimensions study. *Educational Evaluation and Policy Analysis, 2*, 7-25.

Drift, K.D., van der & Vos, P. (1987). *Anatomie van een leeromgeving: een onderwijseconomische analyse van universitair onderwijs.* [Anatomy of learning environment: an education economics analysis of university education]. Ph-D thesis, Lisse: Swets & Zeitlinger.

Dolmans, H.J.M., Gijselaers, W.H., Schmidt, H.G., & Meer, S., van der (in prep.). Content coverage in problem-based curricula. Studies on problem characteristics and learning issues.

Fredrick, W.C. & Walberg, H.J. (1980). Learning as a function of time. *Journal of Educational Research, 73,* 183-194.

Gettinger, M. (1983). Effects of learner ability and instructional modifications on time needed for learning and retention. *Journal of Educational Research, 76,* 362- 369.

Gettinger, M. (1984a). Achievement as a function of time spent in learning and time needed for learning. *American Educational Research Journal, 21,* 617-628.

Gettinger, M. (1984b). Individual differences in time needed for learning: a review of the literature. *Educational Psychologist, 19,* 15-29.

Gettinger, M. (1985). Time allocated and time spent relative to time needed for learning as determinants of achievement. *Journal of Educational Psychology, 77,* 3-11.

Gijselaers, W.H. (1988). *Kwaliteit van Onderwijs Gemeten.* [Measuring instructional quality]. Ph-D Thesis, Maastricht, the Netherlands: University of Limburg.

Gijselaers, W.H. & Schmidt, H.G. (1990). The development and evaluation of a causal model of problem-based learning. In: Nooman, Z., Schmidt, H.G., Ezzat, E. (Eds.). *Innovation in medical education: an evaluation of its present status.* New York: Springer Publishing Company.

Glaser, R. (1991). The maturing of the relationship between the science of learning and cognition and educational practice. *Learning and Instruction, 1,* 129-144.

Moust, J. (in preparation). *Undergraduate teaching assistants as tutors in problem-based learning.* Ph-D Thesis, Maastricht, the Netherlands: University of Limburg.

Schmidt, H.G. (1983). Problem-based learning: Rationale and description. *Medical Education, 17,* 11-16.

Vos, P. (1985). Independent study as a function of class attendance. *Tijdschrift voor Onderwijsresearch.* (Journal of Educational Research), *10,* 228-238.

Walberg, H.J. (1988). Synthesis of research on time and learning. *Educational Leadership, 45,* 76-85.

Walberg, H.J. & Tsai, S.-L. (1984). Reading achievement and diminishing returns to time. *Journal of Educational Psychology, 76,* 442-451.